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METHODS OF TRACING CONSTELLATIONS.

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For THE MESSENGER.

It has always seemed to the writer that the student in astronomy ought to be able to locate the positions of the principal stars visible in the heavens at any assumed time, and to give their names, by some method in which memory plays a less prominent part than in the ordinary way of locating constellations by a knowledge of the configuration of the brighter stars. Even if the student has a star map, he finds it a difficult matter to use it on account of the ever changing form of these configurations with respect, for example, to the horizon. If the student were able to construct his own chart easily and with little loss of time, the problem of tracing constellations would be reduced from bewildering guess-work to certainty.

After a trial of the method proposed in this paper with college classes for two years, sufficient experience has been gained to warrant the conclusion that this method of presenting the subject awakens enthusiasm and gives to the average student a far better knowledge of all the problems which relate to the celestial sphere than the usual method is likely to give.

It is proper to say at the outset that this paper is not written for astronomers. It is written for the benefit of the ordinary academic and collegiate student who is pursuing the study of astronomy for the first time. It will be seen at once that there is nothing new about the method proposed except its adaptation to the needs of the average student.

We start with the statement that the position of a star upon the celestial sphere is to be determined in precisely the

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same way that we locate a point upon the surface of the earth, viz.: by means of its longitude and its latitude. We first assume a primary circle, viz.: the equator. From the pole of the primary circle, or the extremity of the earth's axis, we draw a secondary circle through some point which we assume as the zero of longitude, *e. g.*, Washington, and extend it until it intersects the equator. This point will be the zero of the co-ordinates from which all longitudes are to be reckoned. We next draw another secondary circle through any selected point on the earth's surface, and extend it till it intersects the equator. Then the distance from this point of intersection to the zero of co-ordinates measured *on the primary circle* will be the longitude of the place, and the distance from this intersection measured *on the secondary circle* to the point will be its latitude. The longitude and the latitude taken together form a *system of co-ordinates.* In the determination of the position of a point upon the celestial sphere, four systems of co-ordinates are in common use. As will be seen presently each system has certain advantages peculiar to itself. Since each system has its own primary circle, its own secondary circle and its own zero of co-ordinates, it is necessary to define these circles of reference and these points of reference.

The great circles of the celestial sphere which are employed as reference circles, may be defined as the circles described upon the celestial sphere by the extension of the planes of the great circles of the terrestrial sphere until they cut the celestial sphere. The three primary circles which are employed in the location of a point upon the celestial sphere are the equator, the ecliptic and the horizon. The poles of these circles are, of course, the points on the great circle passing through the zenith of the observer and the pole of the heavens which are 90° from their respective primary circles. If we designate the pole of the equator by P, the pole of the ecliptic by P' and the pole of the horizon by Z, we can conveniently designate all great circles which pass through these points as P-circles, P′-circles and Z-circles respectively.

The points which are assumed as the origin of co-ordinates are as follows:

For the equator. 1. The intersection of the ecliptic with the equator or the vernal equinox.

2. The intersection of the equator with the meridian passing through the zenith of the observer.

For the ecliptic. The vernal equinox.

For the horizon. The intersection of the meridian passing through the zenith of the observer and the horizon at the south point.

We may define the several systems of co-ordinates by the aid of Fig. 1. This figure is the photograph of a wire globe with a hemispherical cap which has a black-board surface.

In taking the original negative, the pole of the cap was inclined towards the camera in order to show all the elements involved.

FIG. 1.

$V\ \alpha\ V'$ represents a section of the celestial equator.

$V\ \lambda\ V''$ (V'' not shown in the figure) represents a section of the ecliptic.

$V A S$ (S = south point of the horizon, not shown in the figure) represents a section of the horizon.

Having selected a point O upon the celestial sphere, we proceed as follows:

SYSTEM I.

Primary Circle = the equator.

Pass a P-circle through the point O and extend it till it intersects the equator at a.

Then: Va = the right ascension of the point $O = \alpha$
aO = the declination of the point $O = \delta$.

SYSTEM II.

Primary Circle = the ecliptic.

Pass a P'-circle through the point O and extend it till it intersects the ecliptic.

Then: $V\lambda$ = the celestial longitude of $O = \lambda$
λO = the celestial latitude of $O = \beta$.

SYSTEM III.

Primary Circle = the horizon.

Pass a Z-circle through O and extend it to the horizon.

Then: the azimuth of $O = A$
the altitude of $O = h$.*

SYSTEM IV.

Primary Circle = the equator.

Pass a P-circle through O.

Then: $V'a$ = the hour angle of $O = ZPO = \tau$
aO = the declination of $O = \delta$.

For convenience of reference, these elements are given in the following tabular form:

System.	Primary Circles.	Secondary Circles.	Origin of Co-ordinates.	Co-ordinates.
I.	The equator.	P-Circles.	Vernal equinox.	Right Ascen. $= \alpha$ Declination $= \delta$
II.	The ecliptic.	P′-Circles.	Vernal equinox.	Longitude $= \lambda$ Latitude $= \beta$
III.	The horizon.	Z-Circles.	South point of the horizon.	Azimuth $= A$ Altitude $= h$
IV.	The equator.	P-Circles.	Intersection of the circle through P and Z with the equator.	Hour angle $= \tau$ Declintaion $= \delta$

The first system is employed in the catalogues of stars and in the location of the positions of planets, because the origin of the co-ordinates, the vernal equinox, occupies the same

* Not given in figure.

position from year to year with the exception of a slight motion annually in precession.

The second system is mainly used in connection with planetary reductions, on account of the simplicity introduced by referring the position of a planet or a comet to the plane of the orbit of the earth.

The third system has the practical advantage of enabling the observer to locate the position of an object upon the celestial sphere by eye-estimates of the altitude and azimuth, since he always has the horizon before him and the zenith is a well defined point in the heavens. Since, however, every point in the heavens has a motion from east to west through the diurnal motion of the earth upon its axis from west to east, we can only determine these co-ordinates for a particular instant of time.

The fourth system enables us to obtain from the elements given under System I the data required to fix the position of the zenith at a given instant.

From Fig. I we have:

$$V'a = V'V - Va$$

Or $$\tau = V'V - a$$

But $V'V$ is equal to the right ascension of the vernal equinox, since it is the distance of the vernal equinox from the meridian, or rather of the meridian from the vernal equinox. How shall we measure the arc? Let us suppose that there is a bright star exactly at the intersection of the equator with the ecliptic which can be easily recognized. Let us suppose also that before this star reaches the meridian on March 22nd of any year the hands of a clock which will run with a uniform rate have been set at 0*h* 0*m* 0*s*. The moment the star crosses the meridian, the clock is started. If at the end of 24 hours, the hands of the clock point to 0*h* 0*m* 0*s* at the instant when the star again crosses the meridian, it is evident that the face of the clock will indicate the arc of revolution passed over by the star at any time selected during the 24 hours. Such a clock is called a sidereal clock. It indicates the sidereal time of the vernal equinox which we designate by S. T.

We have, therefore: $\tau = \text{S. T.} - a$ (1)

When τ is given and a required: $a = \text{S. T.} - \tau$ (2)

When a and τ are given: $\text{S. T.} = a + \tau$ (3)

We must now connect the sidereal time with the mean time, since the value of S. T. will be required for some instant of mean time. Let us suppose that the sun and the star cross the meridian at the same instant on March 22nd. Since the sun moves eastwardly with a mean motion of 360° in one year, or of 236.555*s* in one day and of 9.8565*s* in one hour, it is clear that the star will gain on the sun in its westward motion.

Hence, to find the sidereal time corresponding to any given mean time, we must add to the assumed mean time 236.555*s* for each day and 9.8565*s* for each hour after the beginning of any day for which the sidereal time of mean noon is given. The sidereal time of mean noon is given in the Nautical Almanac for each day of the year. It will be advisable, however, for the student to make the computations for himself from two dates as a check upon the work. For the purpose in hand, it will be quite sufficient to use the sidereal time of Washington mean noon.

In order to reduce the size of the factor of 236.555 it will be convenient to take from the Almanac the sidereal time of mean noon for the first day of each month. The student can then select the value which is nearest the date required. The following values are taken from the Nautical Almanac for 1889-90:

	h m s		h m s		h m s
Jan. 1,	18 46 9.15	April 1,	0 40 59.05	Aug. 1,	8 41 58.89
Feb. 1,	20 48 22.41	May 1,	2 39 15.66	Sept. 1,	10 44 12.08
Mar. 1,	22 38 45.92	June 1,	4 41 28.90	Oct. 1,	12 42 28.66
Mar. 22,	0 1 33.52	July 1,	6 39 45.62	Nov. 1,	14 44 41.82
				Dec. 1,	16 42 58.50

As an example we require the sidereal time corresponding to April 6, 1889, at 9*h* 12*m* P. M., Washington mean time.

h m s	From March 22.	h m s	From April 1.
0 1 33.52	= S. T. W. M. N.	0 40 59.05	= S. T. W. M. N.
0 59 08.32	= 15 × 236.555	0 19 42.78	
9 12 0.00		9 12 00.00	
0 1 30.68	= 9.2 × 9.8565	0 1 30.68	
10 14 12.52	= S. T.	10 14 12.51	= S. T.

Having found the value of S. T. for any assumed time and having at hand a catalogue from which the values of α can be taken, the computation of the hour angle τ by equation (1) becomes a very simple matter.

LOCATION OF STARS BY MEANS OF THE "STAR-FINDER."

Even when the values of α and τ are given, the student will find it exceedingly difficult to locate by eye-estimates the position of a star on account of the difficulty of keeping in mind the position of the celestial equator. With the aid of a very simple piece of apparatus which I have called a "star-finder," the location becomes very easy. It is shown in Fig. 2. The hour circle, attached to the end of the polar axis is graduated to hours and tenths of hours. A circle graduated to degrees is attached permanently to the polar axis

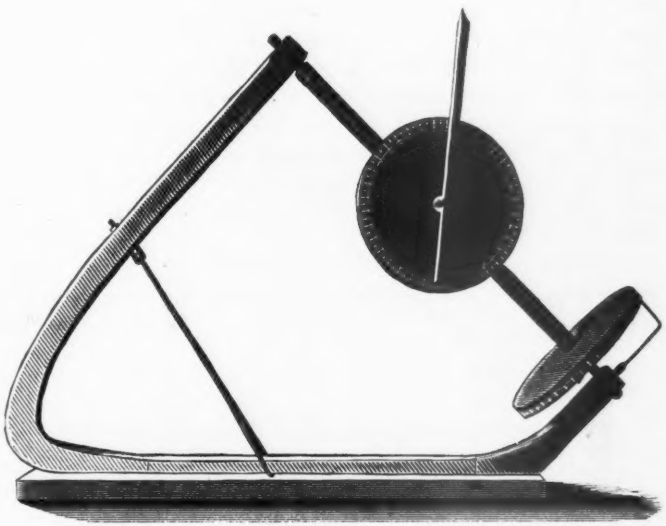


FIG. 2.

near the middle point. An arm of wood works about a pivot fastened at the center of this circle. A piece of tin, painted black except at the upper edge, is attached to this arm in a vertical position. This constitutes the declination-pointer. When the edge of the arm is set at 0° on the circle, the pointer is directed towards the celestial equator. When set at any given declination, it describes the diurnal circle corresponding to this declination when the polar axis is revolved. In order to prepare the instrument for use, place it

in the meridian of the observer and set the base approximately in the horizontal plane by means of a spirit level. If the sidereal time is given, we have only to set the declination pointer for a known declination and revolve the polar axis till the pointer of the hour circle indicates the given hour angle. By sighting along the edge of the tin, the object sought will be readily seen. If the real sidereal time is not known, as may often happen from not knowing the exact local mean time, it can be determined from equation (3) by selecting two bright stars whose co-ordinates are known, one east and the other west of the meridian. Direct the pointer to these stars, read off the hour angle from the hour circle in each case, and find the values of S. T. from equation (3). The mean of these two values will give the value of the sidereal time nearly free from an erroneous adjustment in the meridian and with sufficient precision for the work of the evening.

The computation of the hour angles should be made in advance according to the following scheme:

Example: Locate the position of the following stars for April 6, at $9.2h$ P. M.

S. T. for April 6 at $9.2h = 10.24h$,

Star.	Magnitude.	δ	α	S. T. $-\alpha=\tau$
		°	h	h
α Andromedæ	2.0	$+28.5$	$+0.04$	10.20
α Persei	2.0	$+49.5$	3.29	6.95
ζ Eridani	3.0	-5.2	5.04	5.20
α Aquarii	3.0	-0.9	22.00	12.24
α Pegasi	2.0	$+14.6$	22.99	11.25

It is the experience of the writer that the student can locate from thirty to forty stars during an hour if the values of τ have been computed in advance. Allowance can be made for an extension of the time beyond that for which the value of S. T. has been computed by adding the excess to the computed values of τ.

LOCATION OF STARS BY MEANS OF THE CO-ORDINATES, ALTITUDE AND AZIMUTH.

A little practice will enable the student to estimate altitudes and azimuths with considerable precision, but the following simple and inexpensive apparatus will be found to offer many advantages:

A wooden frame, *A*, is suspended freely from the point *C*. This frame has an altitude pointer, *P*, and an azimuth pointer, *P′*, which swings freely with the frame a little above the top of a table upon the surface of which a circle *B* is graduated. The only adjustments required are, the shifting of the point of contact at (*a*) till the edges of the frame are vertical and setting the table so that the line of the circle *B* from 0° to 180° shall be in the meridian of the observer.

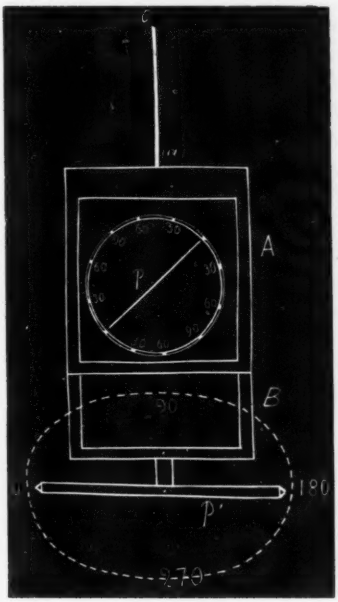


FIG. 3.

It has been assumed thus far that the co-ordinates, altitude and azimuth, are known. It is now required to find some method of obtaining these quantities quickly and by means within the reach of the student. Three methods are available:

First, By means of the hemispherical globe. After tabular values of the hour angle have been prepared for the stars whose locations are sought, we proceed as follows to obtain the corresponding altitudes and azimuths. The zero of a quadrantal circle, which is a secondary P-circle, is placed at the pole of the equator, *P*. It is extended a little beyond the equator. The arc is then swung about the point *P* until the point which intersects the equator marks the given hour angle. The declination is then read off on the secondary P-circle and the point is marked upon the sphere. The zero of the quadrantal arc is then placed at the zenith, and with this point as a pole it is passed through the point just found and extended to the horizion. The azimuth is then read off on the horizon and the altitude on the vertical circle. In Fig. 1 the quadrantal arc intersects the equator at *V″* and the point *O* is laid off on the secondary circle *PO*. Then the quadrantal

arc is made to pass from Z through O till it intersects the horizon at A. $S\ A$ will then be the azimuth and $A\ O$ will be the altitude.

Second, By means of the terrestrial globe.

First measure off the hour angle from the intersection of the equator with the ecliptic. Pass a quadrantal arc from this intersection through the point P. In order to fix the point given by the declination upon the globe without defacement, take from a tumbler of water triangular bits of paper and while wet place the sharpest vertex at the point obtained. Revolve the globe until the vernal equinox makes an angle with the metal arc which surrounds the globe equal to the hour angle. Hold the globe in this position by means of a wedge of wood between the globe and the frame work which represents the horizon. Pass a Z-circle through this point, extend it to the horizon, and read off the co-ordinates required.

Third, By means of an orthographic projection of the diurnal circles described by the stars.

The two methods described above, while they are simple and expeditious, involve the difficulty presented by the limitation that only one or two students can work with the apparatus at one time, and since an unlimited supply of globes is not likely to be available, these methods are hardly adapted to the needs of an instructor who has a large class of students.

We now proceed to describe a method by which the student can construct for himself, a system of right projection of points upon the celestial sphere, upon the plane of the horizon from which he can obtain the altitude and azimuth corresponding to a given hour angle and declination, with a degree of precision considerably greater than can ordinarly be obtained by the use of a globe. The problem may be stated as follows:

Given the position of the point O upon the celestial sphere, by means of its hour angle and declination, it is required to find the azimuth and altitude of the point O' where a perpendicular let fall from O pierces the plane of the horizon.

In Fig. 4, O' is the projection of a point O, which is situated upon the surface of the celestial sphere, upon the plane of the horizon of WNE. ZA is the projection of the Z-circle passing through O.

ZO' is therefore the cosine of the altitude h. But the numerical value of h can be found from the spherical triangle POZ, Fig. 1, in which $PO = 90° - \delta$, $ZO = 90° - h$ and $PZ = 90° - \varphi$. (Since the altitude of the pole P above the north horizon is equal to the latitude of the place of observation.) The hour angle $\tau = ZPO$.

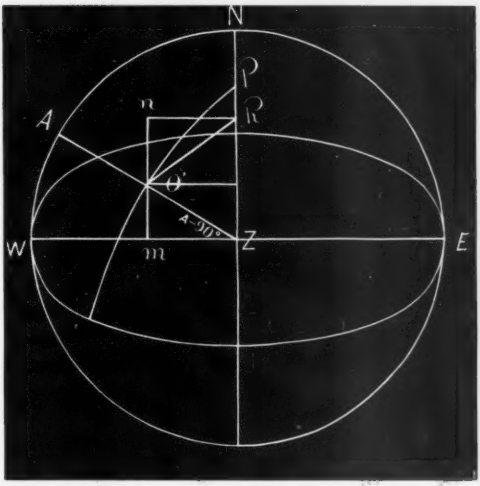


FIG. 4.

We have given in this triangle the parts τ and δ to find h. From spherical trigonometry we have the general relation

$$\cos a = \cos b \cos c + \sin b \sin c \cos A.$$

In order to adapt the triangle to this formula place A at the given angle ZPO and B at the angle PZO.

Then, $\cos(90° - h) = \cos(90° - \delta)\cos(90° - \varphi) + \sin(90° - \delta)\sin(90° - \varphi)\cos\tau.$

or $\sin h = \sin\delta \sin\varphi + \cos\delta \cos\varphi \cos\tau.$

in which all the terms of the second member of the equation are given. Having found the natural cosine of h the line ZO' becomes known.

The direction of the line ZA will be determined by the right angled triangle MZO', in which we have one side given. In order to find the side MZ, proceed as follows: Let fall from the point O upon the surface of the sphere, a perpendicular to the diameter from the center of the sphere through

P. Let R represent this point. From R draw a perpendicular to the same radius in the plane of the great circle passing through the points E, P, W. Also let fall from O a perpendicular until it intersects the last line at the point N. Then $NR = ZM$ since these lines are included between two parallel planes which are perpendicular to the same line.

But $RO' = \sin(90° - \delta) = \cos\delta$; and

the angle $NRO' = 90° - \tau$.

Hence in the right angled triangle $O'NR$ we have

$$NR = \sin\tau\cos\delta = MZ.$$

We have now two sides of the triangle $MO'Z$ from which

$$\cos(A - 90°) = \sin A = \frac{MZ}{ZO} = \frac{\sin\tau\cos\delta}{\cos h}$$

Collecting the formulæ we have:

$$\sin h = \sin\delta\sin\varphi + \cos\delta\cos\varphi\cos\tau \quad (4)$$

$$ZO' = R\cos h \quad (5)$$

$$\sin A = \frac{\sin\tau\cos\delta}{\cos h} \quad (6)$$

For a given hour angle and declination, the corresponding azimuth is obtained by laying off on the horizon the computed value of A. The point O' is then determined by drawing a straight line from Z to the point A and laying off on this line the computed distance ZO'.

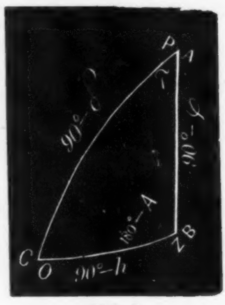


FIG 5.

If the positions of point O are determined for a given value of δ and for successive values of τ; equal, *e. g.*, to 10°, it is obvious that we shall have the projections of a series of points which lie in the diurnal circle described by a star whose declination is equal to the value employed in the computation.

If similar positions of O' are found for diurnal arcs which are, *e.g.*, 5° apart in declination, we shall have a series of points in the ellipses which are the projections of these circles and by drawing P-circles through the points computed with the same value of τ we shall have the projections of the P-circles.

The labor involved in the location of all these points is considerable but in my own case, by assigning to each member of the class a single diurnal circle, the time required for the work was only the time required for the preparation for two recitations. Having arranged the values of A and

ZO' in tabular form, the location of O' was obtained by noting the point on the horizontal circle corresponding to the tabular value of A, and then measuring the distance ZO′ on the line ZA.

The full projections of the diurnal circles and the P-circles are then made by drawing smooth free-hand curves through these points.

But the projections both of the diurnal circles and of the P-circles can be made by the mechanical construction of the ellipses which are the projections of these circles.

PROJECTIONS OF DIURNAL CIRCLES.

Let $x =$ the projection upon the horizontal plane of the meridian altitude of any diurnal circle.

Let $x' =$ the corresponding point at the lower culmination. The minor axis of the ellipse will then be equal to the distance between x and x' and the major axis will pass through a point half way between x and x'. We have then the numerical value of the minor axis and the position of the major axis but not its length.

It will be easily seen that the foci of all the ellipses fall in a circle described about the zenith with the radius, PZ, Fig. 5. For any given case, the foci will be determined by the intersections of the major axis with this circle.

PROJECTIONS OF P–CIRCLES.

In this case we have the major axis equal in every case to the diameter of the horizontal circle. The direction of the axis for a given value of τ is however not given.

The point at which the major axis intersects the south horizon can be found from equations (4) and (6). Since for this case the altitude is zero, equation 4) becomes

$$0 = \sin\delta \sin\varphi + \cos\delta \cos\varphi \cos\tau,$$

$$\text{and } \cos\tau = \operatorname{tang}\delta \operatorname{tang}\varphi. \qquad (7)$$

Substituting in equation (6) the value of τ found from equation (7) we have the azimuth of the end of the major axis from which the position of the axis becomes known.

It will be easily seen that the foci of the ellipse described upon this axis will fall in an ellipse whose foci are the points P and the intersection of the equator with the meridian of the observer, being determined by the intersection of the major axis with this ellipse. The dots in the ellipse, Fig. 6,

represent the positions of the foci with which the projections of the P-circles were described.

METHOD OF USING A PROJECTION-CHART CONSTRUCTED FOR A GIVEN LATITUDE AS SHOWN IN FIGURE 6.

When a chart has been made similar to the one shown in Fig. 6, the positions of the stars of a selected list can be laid off upon it directly with the known values of δ and τ, by es-

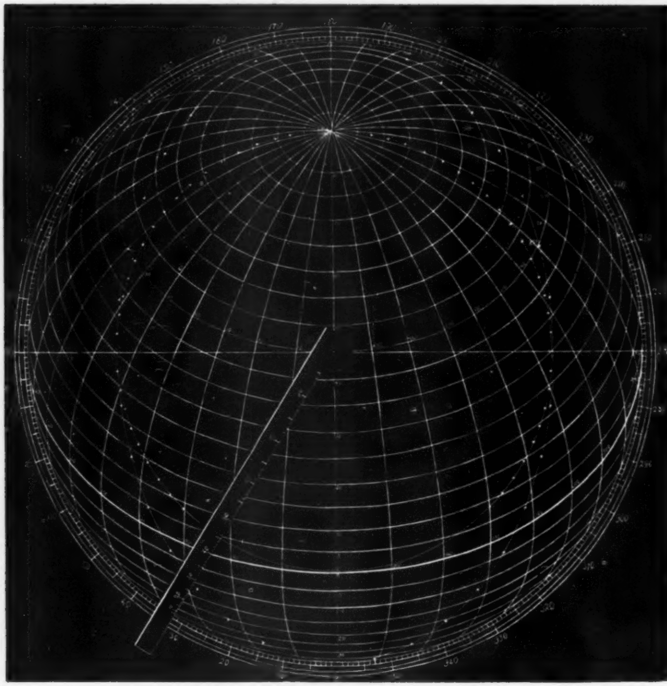


FIG. 6.

timating the position corresponding to the declination upon the line *NS*, then, noting its distance from the nearest ellipse follow the ellipse from east to west till the given hour angle is reached. In the present case the P-circles are separated by intervals of 10°. If a more exact interpolation is desired the intervals must be reduced to 5°.

Since, however, the space upon the chart is largely pre-occupied, it will be found advisable to use this chart only for

the purpose of reading off the co-ordinates in altitude and azimuth, which correspond to the given values of δ and τ. For this purpose a graduated radius is made to revolve about the point Z as a center, as shown in Fig. 6. The distances from the center have been multiplied by the cosine of the altitudes corresponding to the given declinations; hence the altitudes can be read off directly from this radius. Having located by estimation the point corresponding to a given value of δ and of τ, the radius is revolved until the edge falls upon this point. The intersection of the edge with the horizon will give the azimuth, and the graduated radius will give the altitude.

METHOD OF CONSTRUCTING A STAR CHART.

In the method of projection employed there will be no fore-shortening in azimuth, and the fore-shortening in altitude will increase rapidly as we approach the horizon. It will hardly be noticeable at an altitude of 30°. For the purpose of identification it will be sufficient to use a radius subdivided into 90 equal parts instead of the projections of the equal subdivisions of the circular radius. With such a radius and a graduated circle representing the horizon, the positions of a selected list of stars are obtained by using the azimuths and altitudes drawn from the projection-chart as shown in Fig. 6.

The application of this method will be shown in the following example:

Required the azimuths and altitudes of the stars in the "Dipper" for May 11, 1889, at 10*h* P. M.

From April 1. h m s		From May 1. h m s	
0 40 59.05	= S. T. W. M. N.	2 39 15.66	= S. T. W. M. N.
2 37 42.20	= 40 × 236.555s	1 5 25.55	
10 00 0.00		10 00 00.00	
1 38.56	= 10 × 9.8565s	1 38.56	
13 19 19.81		13 19 19.77	

Hence S. T. = 13.32*h*.

Name of Star.	Magnitude.	δ	α h	τ in time. h	τ in arc. °	A °	h °
β	2.0	+ 57.1	10.92	2.40	36.0	131.8	64.7
α	2.0	+ 62.4	10.94	2.38	35.7	143.5	63.1
γ	2.3	+ 54.3	11.80	1.52	22.8	130.0	72.2
δ	3.0	+ 54.7	12.17	1.15	17.2	137.0	75.1
ε	3.0	+ 48.5	12.82	0.50	7.5	127.5	83.8
ζ	3.0	+ 55.6	13.33	23.99	359.9	180.5	79.6
η	2.0	+ 49.9	13.72	23.60	354.0	217.3	83.5

The values of A and h were taken from a projection-chart having a radius of 34 cms. Accuracy sufficient for the present purpose will be obtained if the circle representing the horizon has a radius of 12 cms.

The exact values of A and h will now be derived from formulæ (4), (5) and (6).

For $\varphi = 45°$.

Log sin $\delta = 9.84948$. Log cos $\delta = 9.84948$.

Star.	β	α	γ	δ	ε	ζ	η
	°	′		°	′	°	°
δ	57.1	62.4	54.3	54.7	48.5	55.6	49.9
τ	36.0	35.7	22.8	17.2	7.5	− 0.1	− 6.0
Log sin δ	9.92408	9.94753	9.90960	9.91176	9.87446	9.91651	9.88362
Log sin δ sin φ	9.77356	9.79701	9.75908	9.76124	9.72394	9.76599	9.73310
Log cos δ	9.73494	9.66586	9.76607	9.76182	9.82126	9.75202	9.80897
Log cos τ	9.90796	9.90960	9.96467	9.98013	9.99627	10.00000	9.99761
L'g cos δ cos φ cos τ	9.49238	9.42494	9.58022	9.59145	9.66701	9.60150	9.65606
cos δ cos φ cos τ	.3107	.2660	.3804	.3903	.4645	.3995	.4530
sin δ sin φ	.5937	.6266	.5742	.5771	.5296	.5834	.5409
sum	.9044	.8926	.9546	.9674	.9941	.9829	.9939
Log sin h	9.95636	9.95066	9.97982	9.98561	9.99743	9.99251	9.99734
h	64° 44′	63° 12′	72° 40′	75° 20′	83° 46′	79° 23′	83° 40′
Log comp cos h	0.36971	0.34594	0.52589	0.59654	0.96426	0.73462	0.95738
Log sin τ	9.76922	9.76607	9.58829	9.47086	9.11570	7.24188	9.01923
Log cos δ	9.73494	9.66586	9.76607	9.76182	9.82126	9.75202	9.80897
Log sin A	9.87387	9.77787	9.88025	9.82922	9.90122	7.72852	9.78558
A	131°35′	143°9′	130°37′	137°23′	127°12′	180°18′	217° 37′

When sin δ sin φ is greater than cos δ cos φ cos τ the angle A is to be subtracted from 180°.

ERRORS IN ASTRONOMICAL TEXT BOOKS.

LEWIS SWIFT.*

For The Messenger.

Errors of one kind or another are sure to insinuate themselves into scientific books, regardless of the painstaking care to exclude them exercised by writers and proof-readers. A faultless work on any branch of science, especially on astronomy, has probably never been published, and the most exacting critic, doubtless, does not expect to meet with a perfect volume; yet there are errors extant too obvious to be quietly passed over, to which it seems advisable to call attention. The following are a few I have noticed:

In that most excellent work of Professor Newcomb, "Popular Astronomy," in which are found fewer inaccuracies

* Warner Observatory, Rochester, N. Y.

than in almost any other, there occurs, on page 395, this statement: "In the same year (1819) Dr. C. H. F. Peters, at Naples, discovered a comet of quite short period," etc. Now at that time, as Dr. Peters was but six years old, he was quite unlikely to be searching for comets. Two comets, supposed to be of short period, were found in that year, one by Pons, the other by Blainpain, but the comet discovered by Dr. Peters, in Italy, was Comet VI, 1846. He also discovered Comet IV, 1857, at the Dudley Observatory, Albany, N. Y. On page 403, same work, in speaking of one of the assumed five values for the revolution of the meteoroids causing the November meteoric shower, it says: "The greatest of these values, and the one it seems most natural to select, is that of the mean interval between the showers, or 33¼ years." It is true that the meteoroids complete a revolution in 33¼ years, but whether in half or in ten times that period cannot possibly affect the interval between the showers, as that is governed by the earth's period, or a year. Owing, however, to the motion of the node, each return of the great shower occurs one day later, or once in 33 years and one day. In 1799 it occurred on Nov. 12th; in 1833, on Nov. 13th; in 1866, on the 14th, and it will again repeat itself on Nov. 15th, 1899. Were the text true, the shower of 1866, Nov. 14, would have fallen on the middle of February. Dr. Ball, in his work on astronomy, fell into the same error, but has corrected it in his latest writings. Because of the high authority of these two astronomers, this mistake has been copied in nearly all modern text-books.

The April issue of *The Observatory*, page 206, alluding to the resignation of the Directorship of the Vassar College Observatory, by Miss Maria Mitchell, and her discovery of a comet in 1847, says: "She has the credit of discovering seven other comets." Again the author of "Progress of Astronomy during 1888" (see English Mechanic of Jan. 14th, 1889), referring to her resignation, says: "She is chiefly known in this country as a discoverer of comets." While we would not be ungenerous to this most worthy lady and astronomer, yet, as we seek for truth and not error, we are compelled to assert that but one comet, that of 1847 for which she was awarded the gold medal offered by the king of Denmark, was ever discovered by her.

Lardner's Natural Philosophy, article "Astronomy," third course, page 649, says of former and future pole-stars, that 4,000 years ago Gamma Draconis was the pole-star. In *Astronomy Simplified* by F. A. S. Rollwin, page 208, is found the same statement. This recalls to mind that, on the occasion of a lecture on astronomy which the writer once gave and in which he stated that 4,200 years ago Alpha Draconis occupied the position of pole-star, a gentleman in the audience rose to correct his statement declaring that from the books Gamma was then the pole-star. The lecturer, by drawing the precessional circle round the pole of the ecliptic, convinced him of his error.

On page 409, Lardner says, "The greatest possible duration of a total solar eclipse is the time necessary for the moon to gain upon the sun 122″; it follows that the duration of a total solar eclipse can never exceed four minutes." Truth is, totality may continue nearly twice that length of time.

Astronomy Simplified, page 20, declares that "according to Struve (?) the star Castor (Alpha Geminorum) is one of a ternary system consisting of three suns. . . . This star has completed an entire revolution in its orbit since 1790." The fact is, the two stars, nearly equal in magnitude, have, during the last one hundred years, moved so little that astronomers are in doubt whether the motion is orbital or not. On page 196 is the astonishing statement that "Every time it (Mercury) completes a revolution in its orbit, it makes a transit of the sun."

Chambers' Astronomy, page 346, gives the number of apparitions of Halley's, Encke's, Biela's and Faye's comets correctly, but quite erroneously adds, "and two each of the following," giving dates, fifteen of them, but not one of these has been proved by a second return to be an elliptic comet.

Again on page 39, first edition, the maximum distances of Mars, Jupiter, Saturn and Uranus are placed in the minimum column, and *vice-versa*, while the distances of Mercury, Venus and Neptune are properly recorded.

Lockyer in the first edition of his astronomy, gives, in two places, the equatorial diameter of the earth as 7901 miles, and, on page 65, makes the polar diameter greater than the equatorial. On page 100, writing of solar eclipses, he says

curiously enough, "As the moon, which throws the shadow, revolves from west to east in a month, while the earth's surface on which it falls rotates from west to east in a day, the shadow travels more slowly than the surface and so appears to sweep across it from east to west with great rapidity." It is difficult to conceive how this distinguished author could have made so inaccurate a statement. Another erroneous declaration, and one which appears in several text-books, is found on page 206, article 446, as follows: "As it is, however, the line joining the aphelion and perihelion points, termed the line of the apsides, slowly changes its direction at such a rate that in a period of 21,000 years it makes a complete revolution." As the annual amount of the motion equals only 11.″29, and as there are 1,296,000″ around the sky we find, by the simple division required, the period to be 115,000 years. The 21,000 years of our author has reference to the motion of the apsides coupled with that of precession, which two are in opposite directions. The two phenomena are utterly unlike and produce entirely different effects.

From a long list of misstatements found in Bishop Warren's charming work, *Recreations in Astronomy*, now adopted by the Chautauqua circles as a text-book, I select the following: [Page 24] "We see the light reflected from the new moon to the earth; reflected back from the housetops, fields, and waters of earth to the moon again, and from the moon to us once more" . . . "and thus we see the old moon in the arms of the new." It is not moonlight but sunlight that causes the dark part of the moon to be faintly illuminated After the sun has set, say, in London, it is shining over the entire American continent and it is this sunlight reflected from the earth to the moon and, from the moon back again that causes the phenomenon observed. On page 196 it says: "So that the famous star, 61 Cygni, is the 111th star in brightness in that one constellation." The fact is, it is called 61 Cygni because it is the sixty-first star in the order of Right Ascension in that constellation. Pages 26 and 214 contain assertions often found in astronomical books, viz.: that sunlight coming to us through fog or a cloud is red, whereas it is, in truth, as white as burnished silver, though, reaching us through smoky haze (dry fog) it

always appears red, especially when near the horizon. I question whether the cause of this be exactly known. It is not enough to declare as is often done that the red ray has greater momentum and can force its way through obstructions while the others are absorbed. Were this true, then sunlight through a block of glass or of ice ought to be red, while it is in fact green. In a recent visit to Mt. Hamilton, Cal., the writer saw many red sunsets almost as brilliant as those of three or four years ago. In his opinion, only for the presence of dust of some kind in the atmosphere, the sun would always set white.

This list of errors in our works on astronomy might be greatly extended, but I forbear.

NOTE ON THE PROPER MOTION OF BRADLEY'S STARS.

BY TRUMAN HENRY SAFFORD.*

For The Messenger.

Bradley's catalogue by Professor Auwers has not yet been published, or, at least, sent to America, so far as I can find out; we here have Vol. II of the work, which contains Bradley's own positions in detail, but not the catalogue, which contains the proper motions.

I have consequently extracted from the "Positions Moyennes de 3542 Étoiles (the Pulcova catalogue for 1855), the proper motions of the stars there given, mostly below the 4th magnitude, and from "Publication 14 der Astronomischen Gesellschaft," those of the brighter ones; the two catalogues are complementary to each other in this respect.

As the boundary of the Pulcova catalogue of 1855 is —15° of south declination, I have extended the list of proper motions taken from Publication 14 to this parallel,by extracting from Publication 17 the few stars between —10° and —15° which are of the 4th magnitude or brighter.

The few stars of the magnitudes 1–4 which are not in Bradley have been included, as their proper motions have been calculated.

The number of stars and of proper motions greater than 0″.1 of a great circle annually are given in the following little table:

* Williams College Observatory, March 7, 1889.

	Magnitude.	No. Stars.	P. M. 70″.10	Per Cent.
Fundamental stars..................	1.0 to 4.0	328	149	45
Other stars..............................	4.9 or brighter.	249	73	29
Stars......................................	5.0 to 5.9	823	202	25
"	6.0 to 6.9	1117	215	19
"	7.0 or fainter.	280	48	17

That is, of the 328 fundamental stars, 149 or 45 per cent have proper motions greater than 0″.10 annually; and so on.

From this it will be seen that the percentage of sensible proper motions of the fainter stars is not very small; I adopted 0″.10 yearly as my lower limit, thinking that very few stars indeed could be erroneously assigned proper motions of this amount, even supposing Bradley to have a single observation only; or that the proper motion in one co-ordinate depends on Piazzi or Groombridge.

The logarithms of the percentages are roughly represented by the formula

$$h = -0.06 - 0.1m$$

which of course gives an absurd result for $m = 1$, but elsewhere is not far from the truth. For the magnitudes 7.0, 8.0 and 9.0 the percentages of proper motion greater than 0″.10 annually would be: 7th magnitude, 17th per cent; 8th magnitude, 14 per cent; 9th magnitude, 11 per cent. That is to say, the 110,000 stars not in Bradley's catalogue which have been observed in the zones of the Astronomischen Gesellschaft may be expected to furnish at least 12,000 proper motions greater than 0″.10 yearly, so soon as a value of that amount can be distinctly recognized.

If the older observations to be had in any case are Lalande and Bessel's or Argelander's zones only, the probable error of an annual proper motion (including both co-ordinates) will be somewhere between 0″.02 and 0″.03; Piazzi or Groombridge would most likely reduce this amount to 0″.015 or 0.″02; while all the authorities of 1790–1810 should not have a greater uncertainty than 0″.01 to 0″.015, provided the star is found in all three catalogues, or is twice or more observed by Lalande, and is in one other. In these rough estimates I have supposed the modern authority to have a probable error of 0″.5, or of 0s.024 read in right ascension, and 0″.35 in declination—which is probably an average value for the two or three observations of the zones after

Astronomischen Gesellschaft—and have taken the mean epoch as 1875.0.

An equally accurate repetition of these zones in 35 years would give the probable error $\pm 0''.02$ for the annual proper motions of stars not observed before the present zones were begun in 1868, so that it will be hardly time to undertake it for this purpose.

The non-fundamental work for first rate meridian instruments which seems to me most important at the present time is the re-observation of stars of the 7th and 8th magnitudes, especially such as are either contained in Piazzi or Groombridge, or give in other ways indications of sensible proper motion. The proper motions averaging $0''.10$ annually have now a very great importance in the problem of the solar motion and its relation to the stellar distances.

I am just publishing a catalogue of polar right ascensions which will furnish in one way a basis for these observations.

TOTAL ECLIPSE OF THE SUN, JAN. 1, 1889.

HON. C. W. IRISH.*

For The Messenger.

Liegan is a new town situated on Section 13, in Township 27, N. R. 16 E. Mt. Diablo Meridian, and is 6½ miles west from the 120th meridian. In time it is approximately 8*h* 00*m* 29.4*s* W. of Greenwich; in latitude approximately 40°9¾′ N.; altitude 4,050 feet above the sea. The altitude was given me by L. F. Warner, Esq., chief engineer of the N. C. and O. Ry., and is determined with accuracy by engineers' levels.

The weather for several days before the 1st was very cloudy, so much so that only an approximate meridian could be obtained, and no observations of precision could be made for obtaining local time, until noon of the 1st. Clouds attended us then and until time of first contact, but did not materially interfere with us after that. The upper regions of the atmosphere were much disturbed by a warm S. E. current, coming in contact with a cold one from the west. This gave the air in the vicinity of the eclipse much tremu-

* United States Surveyor General of Nevada, and Director of the Nevada State Observation Party; Observing Station was at Liegan, California, at the present terminus of the California and Oregon Railway.

lous motion at about the time of first contact, but during totality and on to the end of the eclipse, it was hardly noticed.

After the fourth contact clouds again gathered, and at sundown shut the sky entirely from view.

I was assisted by Professor C. W. Friend, of Carson, Nev., who took the contacts, assisted by Hon. Trenmore Coffin. I myself took the contacts, assisted by Mrs. C. W. Irish.

I put the photographic work into the hands of Professor E. P. Butler, of Reno, Nev., and Mr. James W. Moffat, C. E., of Silver Peak, Nev. Professor Butler was assisted by Mr. Sidney Pinniger, who changed the plate holders for him, and Mr. Moffat by Professor Wm. McN. Miller of the Nevada State University, who preformed the same service for Mr. Moffat. Professor Miller joined the party for the purpose of making meteorological observations of his own, and, as I was short a man for the photographic work, he kindly volunteered for the purpose. Mr. J. S. Hawkins of Carson, Nev., by means of a sighting tube and tangent screw attached to the platform upon which the photographic cameras were fixed, kept these instruments pointed upon the sun, and Mr. L. F. Warner called the times the exposures began, from the face of the chronometer and recorded them.

As I was watching for first contact I had the good fortune to catch a view of the moon as it closely approached the sun.

I could not see the entire body of the moon, but only a crescent-formed part of it. An arc of about 45° in extent was plainly seen; it was of a silvery gray tint, very sharp and well defined on edge next to the sun and fading away to invisibility, and was lost at about 20° each way from the point nearest to the sun.

It was in breadth about one-third the diameter towards the center of the moon from the advancing edge.

Thus I was able to call time of exact contact, and half a second later saw the black edge of the moon's disk overlap the brilliant limb of the sun.

The photographic party now began their work, taking several drop-shutter views of the partial phases.

As the total phases approached closely, I could plainly perceive that yellow rays predominated in the waning sun-

light; all things illuminated by it wore the ghastly livid look as if illuminated by a salted flame.

The landscape partook of this deathly pallor. A few seconds before second contact, diffraction bands began to appear, their lengths disposed north and south, and their motion towards the east. I saw them at first faintly depicted upon the canvas of my tent, and as they brightened they were seen creeping along the ground surface. Their motion I judged was about from 6 to 10 feet per second eastward.

When the instant of the second contact came, the sun's light seemed to leap out of that point of the moon's limb where contact took place, and springing around the circle of the moon in opposite directions, clasped it as if in a pair of loving arms. At the same time the corona, which before was faintly seen, flashed out upon the ashy purple sky. At the end of this article I give four sketches made by members of the party, second and third are duplicates. The corona had two double pointed rays, one of them about tangent to the sun's upper limb, the other tangent to the lower limb. The outer edges of these rays were straight lines, or nearly so; they appeared to me to be exactly parallel, and if they deviated in their lengths from a straight line, it was where they came in contact with the sun's limb, where they seemed to curve outward around it. The rays had a direction in space, upward, from a line through the sun's center parallel with the horizon, of about 27°, rising towards the east. The westward point of the upper ray reached out towards the west about 1½ diameters of the sun from its center, and the eastward point towards east 1¼, the westward point of the lower ray 2, and its eastward point 1½ such diameters. The inner edges of these rays curved inward towards each other, and meeting, formed a fringe of pure white light to the sun's limb about ½ diameter broad. The two western rays, together with the included fringe, were by far the brightest part of the corona, while the two eastern were, with their included fringe, the faintest.

The upper eastern ray was much the weakest of all. The corona in density, brightness and species of its light, reminded me strongly of the great nebula of Orion when I view the latter with my 4-inch telescope with a power of 20

I saw several stars in vicinity of the eclipse twinkling brightly; and, on looking overhead eastward and northward, saw many more, but I was too much occupied in sketching the corona to take any note of them. The sun's polar rays flashed out in a broad fan from both poles; and extending, as I judged, ¾ of a diameter, they blended with the corona's light and gave to that its southward curved appearance. I paid but little attention to the sun's inner corona, as I had not the time to do so. The red prominences were quite evident to the unaided eye, principally on the western limb of the moon.

A short view of them with my telescope showed the two which were noted by the observers by naked eye observations, to be enormous in proportions. The one in the axis of the upper western ray was sharply spear-shaped, and, doubtless, of quite recent formation. Its shape and appearance reminded me strongly of a view I had, some years since, of the formation of just such a figure on the sun's surface in pure white.* The other prominence, which appeared in the axis of the lower western ray, was cone-shaped, the apex bent upward somewhat, and from it there floated off three beautiful roseate clouds, in the direction to which the bended apex pointed. These clouds were cumulus in form.

A number of small and very red prominences appeared in the axis of the lower eastward coronal ray; they seemed to be just forming. In the base of the upper ray near to its outer edge appeared a cone-shaped prominence, having a hue of ashes of roses. It was evidently dying away, for it seemed to be settling down to the surface of the sun. The red points of other prominences could be seen peeping up from behind the black limb of the moon, but I took no further note of them. The photosphere, to my eye, had the appearance of a rose-colored spherical shell, enclosing the sun at a distance of one-twentieth of his diameter from him, and to be lighted up by roseate fires, which were hidden from my view by the dark body of the moon. After third contact I watched the parts of the beautiful scene as they one by one faded from my view.

The chromosphere parted at the point of third contact and withdrew each way from it to disappear at the opposite

* The SIDEREAL MESSENGER Vol. III, page 186.

side of the moon. It disappeared altogether in about 3 seconds. But the beautiful corona lingered, its eastern rays dissolving in about 15 to 18 seconds, and its brighter western rays in about 20 seconds after third contact.

The diffraction bands and the retreating shadow now claimed my attention. The bands seemed brighter than before totality, and danced along like the reflected sunlight from faint ripples of a broad water surface. Their peculiar motions caused me to remark that their origin might be discovered in the wave-like tremulous motion of the air, described at the beginning of the eclipse. The shadow was seen creeping away eastward, over the plain and along the mountain side, its motion not as swift as I had expected it to appear. I had no trouble in following the limb of the moon to exact fourth contact, and continued to see the slaty silver gray crescent for about three seconds after that.

Again the photographic party took photographs, at convenient intervals of time, of the now declining eclipse, and observers completed their sketches before the figures faded from memory. This was faithfully done, no comment or communication with each other until it was done.

At noon of the 2nd we secured two reliable observations for time over our approximate meridian, and having in the forenoon pulled down our camp and packed our instruments, we left on the N. C. and O. train for Reno.

My observed times of the four contacts, referred to the chronometer, and corrected for its rate, and difference between noon of the 1st and second by our approximate meridian, were as follows: 1st, 0*h* 29*m* 04.6*s* P. M., Jan. 1st, 1889; 2nd, 1*h* 51*m* 15.0*s*; 3rd, 1*h* 53*m* 00.6*s*; 4th, 3*h* 09*m* 55.5*s*.

Professor Friend and Hon. Trenmore Coffin jointly report as follows: "Diffraction bands were not noticed at the beginning of totality. The corona on each side of the sun somewhat resembled an elongated tail fin of a fish, with the outer edge fairly well defined, and with the inner edge shadowing off into invisibility. The four points seemed to extend out into long, single, hair-like rays of indefinite length, losing themselves in the brighter outer sky. Point *d* (Fig. 2) was discernible for at least two diameters of the sun. The relative lengths of the four points were in the order *d*, *b*, *c*, *a*. The rifts in the corona between the points *a*, *c* and *b*, *d* were

deeper, or extended nearer to the sun's limb towards the line *ab*, than on the side of the line *cd*. I made no attempt to observe anything except the form and appearance of the corona, and to look for the diffraction bands before and after totality. The sketch, No. 3, was made in camp at Liegan on the morning of Jan. 2d. It would be difficult if not impossible to represent the corona as it really appeared. In color it was a very light soft yellow, with a greenish tint. The points of the corona, especially the lower right hand point, seemed to extend out into long, luminous hairs, which appeared to float in space. There was a gradual decrease of light from the limb of the sun to outer limits of the corona. Referring to sketch (No 2), there was no sharply defined outline, except a part of line *ab*. Lines *ab* and *cd* should be a little nearer or quite parallel, by widening the space between *a* and *c* and narrowing the space between *b* and *d*. The lines across diagram and about the eclipse are intended to represent very light cirro-stratus clouds, nearly all other parts of the sky being clear. The approach and recession of shadow was not clear cut or well defined. The light faded gradually into dull twilight and *vice versa*. Diffraction bands were not noticed before totality, but were sharply defined for four or five seconds after third contact. They were without perceptible onward motion. They appeared like the quivering light cast upon a wall by innumerable wavelets upon nearly still water in sunlight.

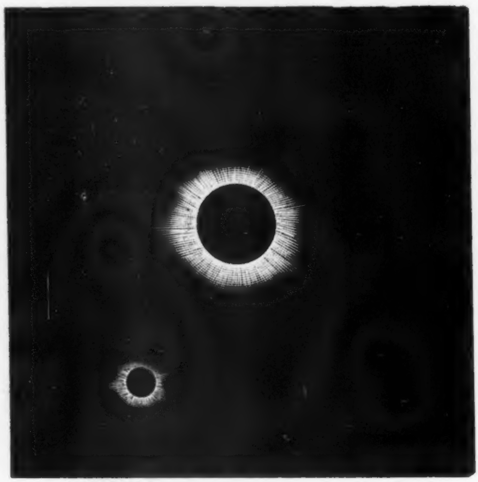
"No candle was necessary for the reading of my watch or to make the drawing during totality. Two small red prominences were seen by the unaided eye. The corona was not visible before second, nor after third contact. Times of observation by Professor Friend;—1st, 0*h* 29*m* 05.4*s* Jan. 1st, 1889; 2nd, 1*h* 51*m* 16.3*s*; 3rd, 1*h* 53*m* 00.3*s*; 4th, 3*h* 09*m* 38.4*s*. Professor Friend concurs in the foregoing which I have written. Very respectfully, TRENMORE COFFIN."

RENO, NEV., Jan. 25, 1889.

Gen. C. W. Irish, Director of Eclipse Observation Party:

SIR: I have the honor to report to you the result of my part in the observation of the total eclipse of the sun on the 1st inst., at Liegan, Cal. I, by your direction, took charge of the Darlot single-view lens and camera. The glass was

eighteen inches back focus, and was about three inches in diameter, with a maximum stop opening one inch in diameter. It was provided with two stops of smaller diameters, but all the work upon the total phase was done with the full opening of one inch. I was assisted in the work at the camera by Professor McN. Miller, who changed plates for me and managed all that part of the work, while I made the exposures and counted the times of the same by the second hand of my watch. Attached is a tabular statement giving the history of each plate. It is as follows:



Photographed by Engineer James W. Moffat.
No. 12, exposure 5s. (The upper figure an enlargement of the lower.)

Photographic Plates Exposed by J. W. Moffat, C. E., and Professor Wm. McN. Miller with the Darlot Lens.

Plate No.	Chron. Time Exposure Began. h m s	Time Exposed.	Remarks.
7	1 12 01	Inst.	View of observation of grounds.
8	1 16 46	"	Partial phase covered by clouds.
9	1 21 02	"	Partial phase, good definitive.
10	1 47 46	"	Shows fan-shaped light.
11	1 51 15	4 sec.	Totality.
12	1 51 28	5 "	Totality.
13	1 52 02	7 "	Totality.
14	1 53 58	5 "	Totality; jarred during exposure.
15	....	....	Not exposed.
16	1 53 01	5 "	Caught by sun at end of totality and jarred.
19	1 58 01	Inst.	Same as No. 10.
20	2 22 47	"	Sun covered by very thin clouds.
21	2 50 48	"	

All the plates used during the observation of the eclipse were "Seed's, sensitometer No. 26," and were developed by myself and Professor Butler, who will give description of the developer used. It is a weaker one than is generally used upon these plates.

I would draw your attention to the peculiar fan-shaped light shown by Nos. 10 and 19, each of which were exposed within four and five minutes of totality, No. 10 before and No.19 after that event. Respectfully yours,

JAS. W. MOFFAT, C. E.

Gen. C. W. Irish, Director of Nevada Eclipse Observation Party:

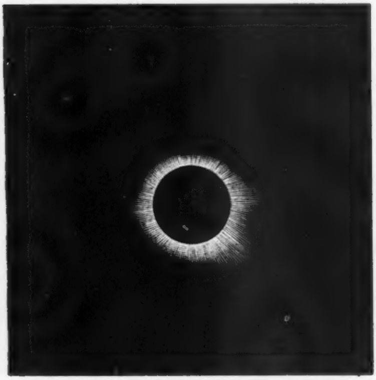
SIR: I take much pleasure in reporting to you, in conjunction with Mr. Moffat, the results of our photographic work on the recent eclipse, Jan. 1st, 1889.

The following table shows a history of the plates which I exposed at the time of total observation, using a Suter lens, Swiss make, No. 3 of the doublet form, 3-inch full opening of the front combination, and 16 inches back focus. It was supplied with three stops, but I used the full opening of 3 inches during the work upon totality. I made the exposures and timed them by counting (mentally) the seconds.

It was a happy conception of yours to experiment with the cameras and lenses by making exposures of some plates sighted upon Mount Rose fifteen miles away after sunset, and the stars had shown themselves in the evening twilight; upon development of these trial plates, the mountain ridge and slopes, together with the figures of the pine trees, came out clear cut, and this with an exposure of only five seconds, with full aperture of the lenses. The developer used upon the trial and eclipse plates, was that of Professor Newton, "standard dry pyro," as follows: One ounce carbonate soda, dry, one ounce carbonate potash, dry, one ounce sulphite soda, dry, ten ounces of water, six grains of pyro, dry, put into four ounces of water and dissolved, to which add two drams of the alkali solution. The mixture makes sufficient developer for a 5 × 8 plate.

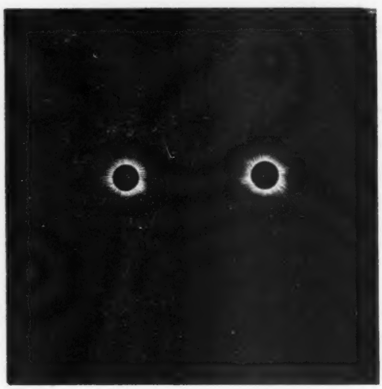
I think, General, that we may congratulate ourselves upon having attained such perfect results, photographically, of all the phases of the eclipse, while using the rude and hastily

improvised stand and appliances, fashioned from materials found upon a desert waste. In conclusion, I have to say that all the plates, whether shutter or cap exposures, show images which come out quite vigorously during development. The cap exposures made during totality with open lenses, though so variously timed, obeyed the requirements of development easily, and without any forcing or prolongation of time or patience.



Photographed by Professor E. P. Butler. No. 36, exposure 5s; enlargement 7:23.

The axis of the platform on which was fastened the cameras in use was so arranged that the Darlot lens, being placed over the pivot about which the whole apparatus revolved, showed less movement and disturbance, from the jarring incident to removing and replacing the plate holders in the cameras, than did the Suter lens, which was farther away from said pivot. I would infer from this, that every camera in such use should have its own separate support.



Photographed by Professor E. P. Butler.
No. 37, exposure 3s. (Right hand figure.)
No. 38, exposure 2s. (Left hand figure.)

The following is a tabulated statement of the plates exposed by me. I took no photographs of partial phases, having no drop shutter to my lens.

No. of Plate.	Chron. Time. h m s	Time Exposed.	Remarks.
33	1 51 15	3 sec.	Excellent, good definition.
34	1 51 41	4 "	Shows signs of jar during exposure.
35	1 52 08	1 "	Badly jarred.

No. of Plate.	Chron. Time. h m s	Time Exposed.	Remarks.
36	1 52 22	5 sec.	
37	1 52 44	3 "	
38	1 53 01	2 "	Caught by end of totality, excellent definition.

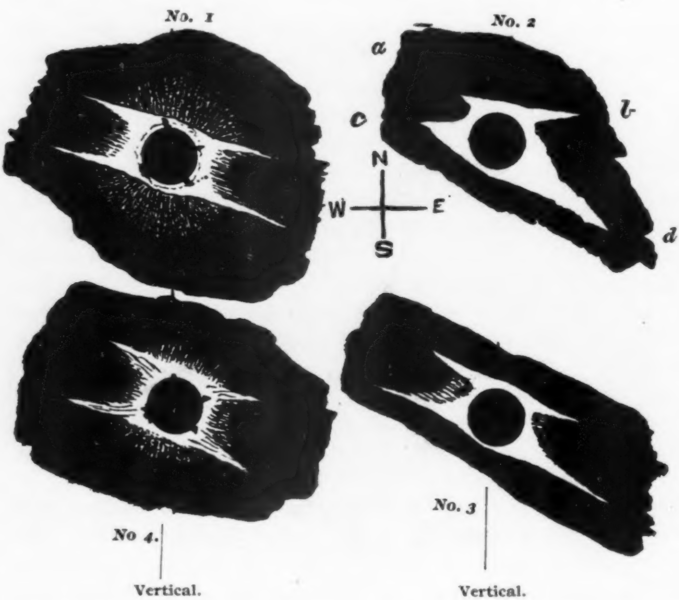
Sincerely yours,
PROFESSOR E. P. BUTLER.

In preparing for photographic work upon the eclipse I was ably seconded by Professor Butler, whose long experience in the lights and shadows of the mountains of California and Nevada was a training much needed for such work. He cheerfully consented to assist, and together we made experiments with the two lenses selected for our work, by exposures of "*Seed's plates*" after sunset at times selected by myself, at which the darkness of receding twilight was first a little brighter than I had, in former experience with total eclipses, observed the light on such occasions to be; and, second, when the still fading twilight was surely a shade or two darker. To this end I selected the pine-covered slopes of the Sierra Nevadas, distant about fifteen miles. The newly fallen snow caused the black pine trees to stand out boldly in relief on the sides of the mountain known as Rose Peak.

We focused the cameras carefully upon the clouds which hovered over the mountains in bright sunlight, and marked the position of the plate carriers, and then on the evenings of December 27th and 28th preceding the eclipse, we pointed the cameras upon the mountain selected, and at twenty-five minutes after sundown, at a time when the unaided eye could clearly make out the pine trees on the mountain sides, made exposures with the medium stops of five seconds; at thirty-three minutes after sunset, exposures of ten seconds, at a time when I judged by the eye that the darkness was about as we might expect it during the eclipse; and again at forty minutes when the pine trees had lost their forms to the eye, and only the bulk of the mountain could be outlined upon the sky, and clouds as a background. At this time we made exposures of from five to ten seconds, with full opening of lenses, getting negatives which not only gave an outline of the clouds and mountains, but also of the pine trees on the darkly shadowed slopes. The figures of the pines are

clear cut, showing that our cameras could catch forms in a light so weak that the eye altogether failed in the attempt to make them out. I found by comparison, on the day of the eclipse, that the darkness was just about equivalent to the forty minutes after sundown experiment.

I here give the four field sketches made at the time of the eclipse, and a photograph from negatives made by each of the lenses used; A by the Darlot and B by the Suter. The figure of the moon in photograph A shows the same cres-



Field Sketches of the Sun's Corona, Jan. 1, 1889, by the Nevada State Observation Party. No. 1 by Gen. C. W. Irish. No. 2 by Hon. T. Coffin. No. 3, by Hon. T. Coffin, is a revision of No. 2. No. 4 by Mrs. Gen. C. W. Irish.

centic reflection as I saw it to have in the telescope, which enabled me to see the moon before the second contact and after the third. Not one of the negatives by this lens shows more than a suspicion of the presence of the red prominences, while in every one by the Suter they strongly appear. We were very kindly treated by the people of Liegan, and owe a debt of gratitude to E. Gest, Esq., Manager, and J. M. Ful-

ton, Superintendent, and to Mr. L. F. Warner, Chief Engineer of the N. C. & O. Ry. Co., for transportation and other help furnished the expedition, without which we could not have succeeded.

THE CARLETON COLLEGE ECLIPSE PARTY.

A brief report of the work of the Carleton College observing party made Jan. 1, 1889, may be given at this time. The party consisted of Professors Payne, Pearson and Wilson. The instruments taken were, a six-inch reflecting telescope, kindly loaned to the party by Mr. C. E. Crane, of Owatonna, Minn., a zenith telescope of 2½ inches aperture, also loaned to Carleton College by John Bidwell, chief engineer of the Department of Dakota, Fort Snelling, Minn., a chronometer, an aneroid barometer of sensitive pattern for measuring altitudes, fine thermometers and a variety of photographic apparatus.

The route of the party to the Pacific Coast was over the Chicago, St. Paul and Kansas City Railway, and the Atchison, Topeka and Santa Fè Railway. We were surprised and delighted to find the new Kansas City line so complete in all its appointments, for the comfort and pleasure of those who travel by it, although its main line is not yet completed to Kansas City. This new route has quickly come to the front and is one of the best equipped for passenger service in the West.

From St. Joseph, Mo., to San Francisco, California, we were on the Santa Fè cars without change. In this justly famous route we found many things to admire; chiefly the attention and politeness of the employès, and the excellent eating houses for the whole length of the line, furnished by the company, under one management, which is the finest arrangement of the kind we ever saw. The sight-seeing afforded by this route was a continual round of pleasure not soon to be forgotten. The idea that an ordinary traveler, not choosing a Pullman car, may step into a railway coach and not necessarily leave it again until he set foot on the pier at Oakland, California, is one of the marvels of modern trans-continental travel which it is difficult to realize until one has experienced it.

In this connection it is a great pleasure to mention the thoughtful interest and the liberal courtesies in the way of free transportation in the interest of science furnished by President Wm. B. Strong, of the Atchison, Topeka and Santa Fè Railway Company, President Stickney and General Manager Egan, of the Chicago, St. Paul and Kansas City Company, and also the generous offers of like favors by President J. J. Hill and General Manager A. Manvel of the St. Paul, Minneapolis and Manitoba Company. We further delight to speak of the great personal kindness of Mr. Chas. S. Hulbert, of Minneapolis, a member of the Board of Trustees of Carleton College, who generously paid the bills of the party, thereby not only making so expensive and delightful a trip possible to us, but also giving us an opportunity to observe for the first time a total solar eclipse, the grandest celestial phenomenon within the reach of mortal eyes.

The place chosen by our party for observation was Chico, California. This is a city of seven thousand inhabitants, in the Sacramento valley, east of the river bearing the same name, about eighty miles north of the city of Sacramento. The particular point selected for mounting the instruments was on the famous ranch of the Hon. John Bidwell, 32.47 chains, with bearing S. 32° 45′ W. from corner of sections 22, 23, 27 and 36, and on N. E. ¼ of section 27, T. 22, N. R. 1 E. Mt. D. M., variation of needle being 17° east. The survey was made by Engineer M. T. Brown, of Chico.

The telescopes were mounted Dec. 28 and 29, and were ready for observation on the evening of the 29th, but clouds so continually interfered that but a single opportunity was found for taking time and obtaining the approximate latitude of our place. As thus roughly obtained our position was:

Latitude = 39° 43′ 56″ N.

Longitude = $8h\ 7m\ 27.5s$ West of Greenwich.

We were greatly favored by the kindness of the general officers of the Western Union Telegraph Company resident at San Francisco and Sacramento in the free use of the Lick Observatory time signals for five days preceding and including January 1. By this means it was possible to know the error of our chronometer very closely. The morning of Jan. 1 was not altogether favorable, yet there were hopefu

signs, though at 10 o'clock a heavy bank of clouds in the west caused our party to feel more doubtful. The last comparison of the chronometer with the noon Lick time signal was made and we hurried to our instruments to be ready for the first contact. The four contact observations, in Pacific standard time, were as follows:

Contacts observed by W. W. Payne.

Zenith Telescope 2½ inches aperture, power 106.

	h m s		h m s
First contact........................	12 24 31	Third contact...............	Not observed
Second "	1 48 20	Fourth "	3 7 57

Times of contact observed by H. C. Wilson.

	h m s	Instrument.
First contact..............................	12 24 30.5	6-inch reflector.
Second "	1 48 20	1⅝-inch finder.
Third "	1 50 15	1⅝-inch finder.
Fourth "	3 08 02	6-inch reflector.

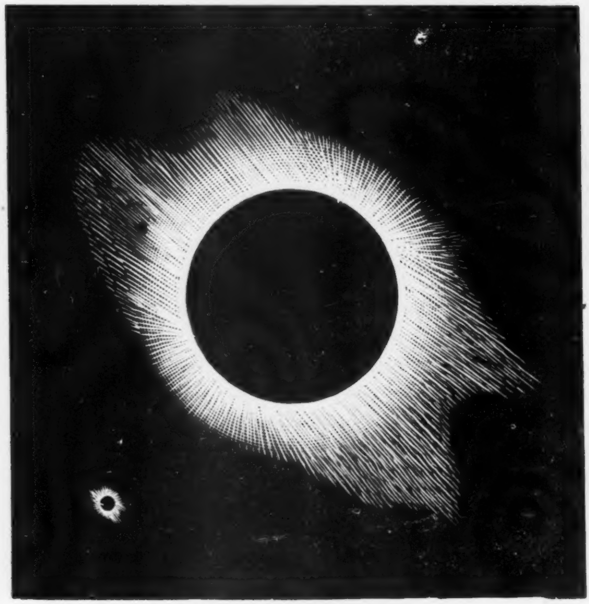
The eye-piece employed with the 6-inch reflector gave a magnifying power of 45, that with the finder about 15.

The chronometer used was by Bond, and numbered 374. It was placed at a convenient distance from the observers, that the counting of time might be distinctly heard by all. Mr. H. H. Camper of Chico did this service for the party in a clear voice, for the entire period of totality.

As before said, late in the forenoon of the day there was some promise of a fair opportunity for observing the eclipse, and at fifteen minutes after one o'clock we felt sure of first contact. A few minutes later a vigorous call of "time" from the observers at both telescopes, at an interval of one-half second apart, was the beginning of the important record. In five minutes more the sun was covered by a large, dense cloud, that had a very depressing influence on our party, for it did not seem possible that such a thick, slow-moving mass could pass by the sun in the short space of twenty minutes, the computed time for the beginning of totality. The moments following were long and painful, and the growing disappointment pictured in every countenance was plainly visible. However, at 1:45 there was a sudden breaking away of the clouds in the immediate vicinity of the sun that was very surprising to the thoughtful observer. If this uncovering of the face of the sun, at the time, had been known to be miraculous, it could not have been more joyfully surprising to the writer. Two minutes more and the thin crescent of

the sun's eastern limb hung on the black moon like a silver thread, its southern cusp broken into two parts which tremblingly linger for an instant and then disappear. The sight in the telescope was beautiful beyond all anticipation.

In searching for the phenomena attending the third contact, its time was not noted. The sudden disappearance of the sunlight, the bursting forth of the corona with its four long and distinct streamers, the effort necessary to sketch an outline of the same, and view its interior structure in the telescope, were the thoughts occupying our minds in the 113

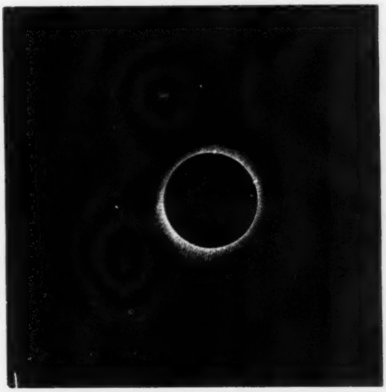


No. 7 of totality. Exposure 1 sec. Plate, Seed No. 26. Instrument, Camera, 2½-inch Darlot lens.

precious seconds of time allotted for these things. The photographic work of the party was given to Professors Pearson and Wilson, and illustrations of part of the same are given herewith with explanation by Professor Pearson as follows:

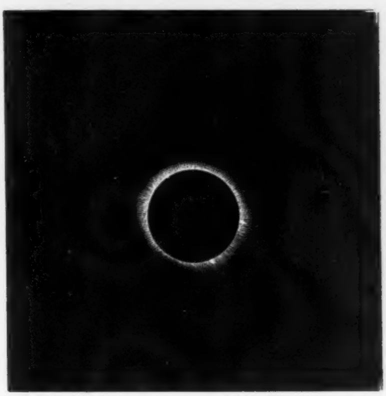
"The instruments used in the photographic observations were a 6-inch reflecting telescope, a 2½-inch projecting lens

of about 7 inches focus, and a couple of Rochester cameras carrying a one inch rapid-working Darlot lens and a Rochester lens, and supplied with 5×8 Seed plates, No. 26. To the upper part of the reflector was fitted a wooden support, one arm of which carried the plate holder for the telescope while the other arm bore the projecting lens fitted into a box which was arranged for receiving 4 × 5 plate holders. The axis of the projecting lens coincided with that of the reflector, so that when the image was upon the crossed wires of the finder of the large telescope it was in the axis of each instrument.



No. 2 of totality. Exposure, 5 sec. Plate, Seed No. 26. Instrument, 6-inch reflector.

"The reflector was furnished with an equatorial mounting so that the proper motion could be given by a turn of the hand. The plate holder of the reflector consisted of an outer square case, within which rotated a hexagonal box, each of whose faces was furnished with a 4×5 plate. Before and after totality this holder gave way to a holder fitted for instantaneous exposures.



No. 5 of totality. Exposure, 10 sec. Plate, Seed 22. Instrument, 6-inch reflector.

"A 5 × 8 Seed plate No. 26, given a short exposure with the Darlot lens at the time of first contact shows the sun and the neighboring sky covered with light clouds whose general drift was to the east and south-east. Occasional instantaneous exposures were made upon Seed plates Nos. 22 and 26,

with the large telescope up to the time of second contact as rifts in the clouds afforded opportunity. The images upon the most of these negatives, while showing well the advance of the moon, were more or less obscured by clouds. The uncertainty concerning the intensity of the coronal light of course rendered necessary as wide a range as possible of exposures during totality. To the image of the reflector received through the side of the tube, exposures of five and six seconds were first made upon Seed plates No. 26, then of seven seconds upon a Seed plate No. 22, then successively of eight seconds upon a Seed 26, of ten seconds upon a Seed 22, and of twelve seconds upon a Seed 26. It was found that the effort to maintain the motion of the instrument would jar the plates, so that attention was confined to bringing the image of the moon to the axis of the telescope in the intervals between exposures. This of course resulted in a decided drift of the image upon the plates during the longer exposures.

"The intensity of the coronal light was underestimated, which appears to have been the case quite generally, and of course the shorter exposures and the slow plates gave the best results. The most satisfactory picture, so far as detail in the corona is concerned, was obtained from the projecting lens by an exposure of one second through the unstopped lens upon a Seed plate No. 26.

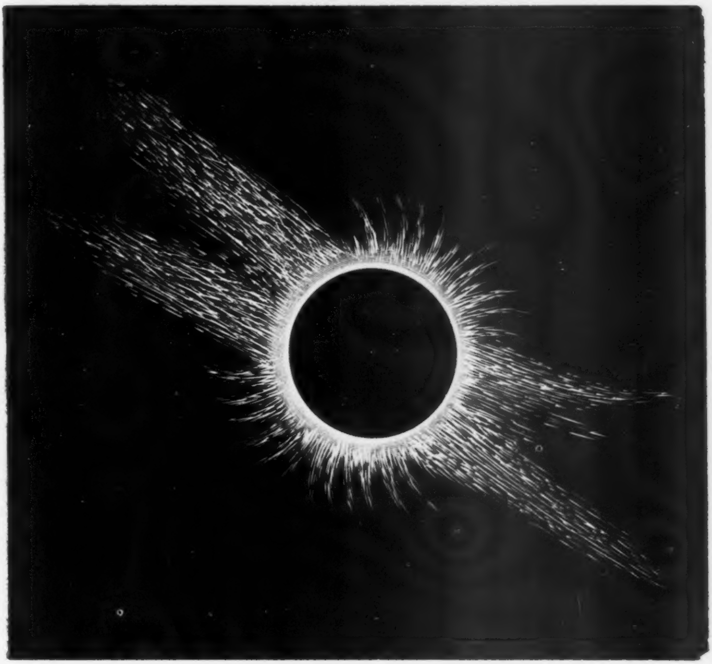
"Exposures of 50 and 60 seconds upon Seed plates No. 22, in the 5×8 cameras of course show over exposure at every point of the drifting image.

"The clearing of the sky a few minutes before totality afforded a fine opportunity for photographic as well as observational work. And the continuance of this condition after totality resulted in a satisfactory set of views of the remaining phases of the eclipse."

Free-hand sketches of the corona were made by Messrs. Coster, Brown and McGann, of Chico, who kindly consented to assist our party in this particular, and whose work was very creditable, and will be embodied in the fuller report of the party that will be published some time during the summer.

The following sketch is by Dr. H. C. Wilson, and the explanation of it is given in his own words, as follows:

"My sketch of the corona was drawn from memory immediately after totality. As I was occupied with the photographic apparatus, guiding the 6-inch reflector, I could spend very little time in looking at the corona with the naked eye. The impression, however, which I received in the few seconds snatched at intervals between exposures, was a very vivid one. My first thought at the moment was that the corona was very like the Trouvelot drawing of 1878, but differing es-



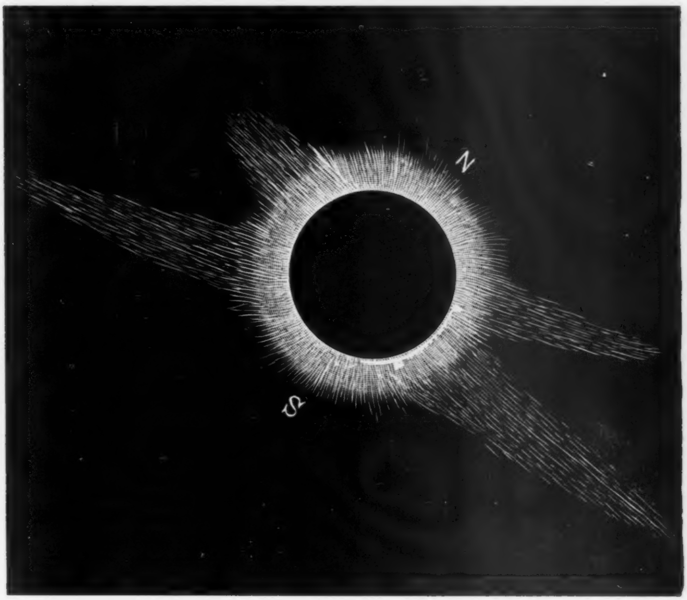
pecially in the polar rays which were curved and pointed, instead of straight and spreading as in the Trouvelot drawing. These polar rays impressed me so forcibly that I have doubtless made them too conspicuous in my drawing. I had no time to count them, so that the number sketched is a mere estimate. The broad bands extending to the east and west were each divided at a short distance from the moon's edge into two faint streamers which reached out to a distance of

two or more diameters of the moon. I may have been confused as to the direction of the two broader ones of these streamers from the fact that I was looking most of the time through the finder, which inverted the image. The upper streamer to the right, as seen with the naked eye, was, I am certain, decidedly curved upward near its extremity. Three rose-colored prominences were visible in the finder during the greater part of totality. I saw the inner corona through the finder several seconds before the beginning and after the end of totality, although a thin neutral tint shade was used. I looked carefully to see the projection of the moon upon the corona before the beginning and after the end of the eclipse, but was unable to see it, as the sky was slightly hazy."

The outline of the figure given below was made by the writer during totality and immediately after it. The time given to observing it was divided nearly equally between views by the naked eye and by the zenith telescope, mainly upon the inner corona. The naked eye view was first in order. Immediately after third contact the corona was examined and the three longer streamers of the figure were distinctly in view, and the fourth was seen, though faint in comparison with the others. At first sight the southern limits of the two lower streamers seemed to make one straight line outside of the corona proper; but the northern limits of the northern pair were not well defined. At the middle of totality the streamers seemed to be wider at their bases, more extended and slightly curved, and the whole corona larger and more symmetrical in the polar regions. The writer thinks that a considerable portion of these changes may not have been real, but rather due to compelling the eye to grasp the view as definitely as possible, which could be done better after a few seconds of steady observation, as his eye is not very sensitive to faint details such as these.

After a few seconds of attention to the sketch, the telescope was turned upon the inner corona of the western limb of the sun to search for Bailey's Beads, and to note the structure of the corona in the few seconds of totality that remained. Beginning in the base of the upper western streamer, and sweeping to the south, we noted the photo-

sphere in full view for 90° to the south, from which arose two large and beautiful prominences; but, knowing that we had less than ten seconds of time left, we took a hasty look at the corona about the south pole, and the view which met our eyes there was beautiful beyond the power of delineation or expression. The view as a whole reminded us of the observations and drawings of Professor Lewis Boss, made at West Las Animas, Colo., July 29, 1878, and published in



the U. S. Naval Observatory Report for 1880, so far as the filaments about the south pole are concerned. With a better means of illustration than we now have at hand we hope in the near future to represent more fully and faithfully what we saw.

We had no means of determining the light of totality, and can only say that it was necessary to use artificial light to carry on our sketching, and that the young men before named were also aided in the same way. Another physical fact of interest was noticed during the progress of the

eclipse. At 12:45 the barometer stood at 30.13, at 1:50 it read 30.03, and at 3:45 the reading was 30.13 again.

The members of our party remember with great pleasure the kindness and helpful attention given them by the Hon. John Bidwell, the owner of that magnificent ranch where our observing position was, and the interest manifested in the success of our observations by Editor Chalmers, of the Chico *Enterprise*, Rev. E. Graham, of the Presbyterian church, and Messrs. Burroughs and Goodyear and many other friends whose names would make a list too long for our space if given here.

CURRENT INTERESTING CELESTIAL PHENOMENA.

THE PLANETS.

	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
MERCURY.					
April 20	1 36.8	+ 8 56	5 02 A.M.	11 40.8 A.M.	6 20 P.M.
25	2 16.0	+13 22	5 03 "	12 00.3 P.M.	6 58 "
30	2 57.4	+17 32	5 06 "	12 21.9 "	7 38 "
May 5	3 39.4	+21 01	5 12 "	12 44.1 "	8 17 "
10	4 19.3	+23 32	5 19 "	1 04.2 "	8 49 "
15	4 55.1	+25 00	5 27 "	1 20.2 "	9 13 "
VENUS.					
April 25	2 39.2	+21 37	4 48 A.M.	12 23.5 P.M.	7 59 P.M.
May 5	2 17.3	+17 53	4 05 "	11 22.2 A.M.	6 40 "
15	2 03.2	+14 10	3 28 "	10 28.7 "	5 30 "
MARS.					
April 25	2 55.6	+16 54	5 46 A.M.	12 59.4 P.M.	8 12 P.M.
May 5	3 38.9	+19 47	5 17 "	12 43.7 "	8 10 "
15	4 08.2	+21 21	5 00 "	12 33.6 "	8 08 "
JUPITER.					
April 25	18 35.9	−22 55	11 52 P.M.	4 17.4 A.M.	8 42 A.M.
May 5	18 35.0	−22 57	11 11 "	3 37.2 "	8 03 "
15	18 32.9	−23 00	10 30 "	2 55.8 "	7 21 "
SATURN.					
April 25	9 05.5	+17 53	11 31 A.M.	6 48.5 P.M.	2 06 A.M.
May 5	9 06.6	+17 47	10 53 "	6 10.4 "	1 27 "
15	9 08.5	+17 39	10 16 "	5 32.9 "	12 49 "
URANUS.					
April 25	13 12.1	− 6 56	5 18 P.M.	10 54.5 P.M.	4 30 A.M.
May 5	13 10.6	− 6 48	4 37 "	10 13.8 "	3 50 "
15	13 09.4	− 6 40	3 56 "	9 33.2 "	3 10 "
NEPTUNE.					
April 25	3 56.8	+18 49	6 19 A.M	1 40.9 P.M.	9 02 P.M.
May 5	3 58.3	+18 52	5 41 "	1 03.1 "	8 25 "
15	3 59.8	+18 57	5 03 "	12 25.3 "	7 48 "

THE SUN.

	R. A.	Decl.	Rises.	Transits.	Sets.
	h m	° ′	h m	h m	h m
April 20............	1 54.8	+11 46	5 08 A.M.	11 58.7 A.M.	6 49 P.M.
25............	2 13.5	+13 25	5 00 "	11 57.8 "	6 56 "
30............	2 32.5	+15 00	4 52 "	11 57.0 "	7 02 "
May 5............	2 51.7	+16 28	4 45 "	11 56.5 "	7 08 "
10............	3 11.1	+17 49	4 39 "	11 56.2 "	7 13 "
15............	3 30.8	+19 02	4 33 "	11 56.2 "	7 19 "

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T.	IMMERSION. Angle f'm N. P't.	EMERSION. Wash. Mean T.	EMERSION. Angle f'm N. P't.	Duration.
			h m	°	h m	°	h m
May 6	35 Cancri	6½	12 33	175	12 50	213	0 17
7	83 Cancri	5½	8 52	186	9 15	220	0 23
8	37 Leonis	5½	12 30	137	13 21	268	0 52

Phenomena of Jupiter's Satellites.

Central Time. d h m		
April 18	1 19 A. M.	I Ec. Dis.
	4 46 "	I Oc. Re.
19	12 50 "	II Ec. Dis.
	1 57 "	I Tr. Eg.
21	12 35 "	II Tr. Eg.
23	12 43 "	III Oc. Dis.
	3 34 "	III Oc. Re.
25	3 12 "	I Ec. Dis.
26	12 22 "	I Sh. In.
	1 30 "	I Tr. In.
	2 37 "	I Sh. Eg.
	3 23 "	II Ec. Dis.
	3 46 "	I Tr. Eg.
27	1 03 "	I Oc. Re.
28	12 25 "	II Tr. In.
	12 50 "	II Sh. Eg.
	3 04 "	II Tr. Eg.
30	12 02 "	III Ec. Dis.
	2 38 "	III Ec. Re.
	4 23 "	III Oc. Dis.
May 3	2 14 "	I Sh. In.
May 3	3 19 A. M.	I Tr. In.
	4 30 "	I Sh. Eg.
	11 35 P. M.	I Ec. Dis.
4	2 52 A. M.	I Oc. Re.
5	12 02 "	I Tr. Eg.
	12 48 "	II Sh. In.
	2 51 "	II Tr. In.
	3 26 "	II Sh. Eg.
6	11 49 P. M.	II Oc. Re.
7	4 01 A. M.	III Ec. Dis.
11	12 27 "	III Tr. Eg.
	1 28 "	I Ec. Dis.
	4 40 "	I Oc. Re.
	10 36 P. M.	I Sh. In.
	11 33 "	I Tr. In.
12	12 52 A. M.	I Sh. Eg.
	1 48 "	I Tr. Eg.
	3 24 "	II Sh. In.
	11 07 P. M.	I Oc. Re.
14	2 11 A. M.	II Oc. Re.

Approximate Times of Transit of the Great Red Spot Across the Middle of Jupiter's Disk.

Central Time. d h m	Central Time. d h m	Central Time. h d m
April 16 4 53 A. M.	April 26 11 00 P. M.	May 8 3 02 A. M.
17 12 44 "	28 4 47 A. M.	8 10 53 P. M.
18 6 31 "	29 12 38 "	10 4 40 A. M.
19 2 23 "	30 6 25 "	11 12 31 "
19 10 14 P. M.	May 1 2 16 "	12 6 18 "
21 4 01 A. M.	1 10 07 P. M.	13 2 09 "
21 11 52 P. M.	3 3 54 A. M.	13 10 01 P. M.
23 5 39 A. M.	3 11 45 P. M.	15 3 47 A. M.
24 1 30 "	5 5 32 A. M.	
24 9 22 P. M.	6 1 23 "	
26 3 08 A. M.	6 9 15 P. M.	

Elongations and Conjunctions of Saturn's Satellites.

[Central Time; E = Eastern elongation, W = Western elongation, S = Superior conjunction, I = Inferior conjunction.]

JAPETUS.

April 16, I May 6, W

TITAN.

d	h		d	h		d	h	
April 18,	6 P. M.	E	April 30,	5 P. M.	S	May 12,	4 P. M.	W
22,	5 P. M.	I	May 4,	5 P. M.	E			
26,	5 P. M.	W	8,	5 P. M.	I			

RHEA.

April 16,	4.4 P. M.	E	April 30,	5.7 A. M.	E	May 13,	7.1 P. M.	E
21,	4.8 A. M.	E	May 4,	6.1 P. M.	E			
25,	5.2 P. M.	E	9,	6.6 A. M.	E			

DIONE.

April 16,	11.7 A. M.	E	April 27,	10.5 A. M.	E	May 8,	9.3 A. M.	E
19,	5.4 A. M.	E	30,	4.2 A. M.	E	11,	3.0 A. M.	E
21,	11.1 P. M.	E	May 2,	9.9 P. M.	E	13,	8.7 P. M.	E
24,	4.8 P. M.	E	5,	3.6 P. M.	E			

TETHYS.

April 16,	11.1 P. M.	E	April 28,	6.8 A. M.	E	May 9,	2.8 P. M.	E
18,	8.4 P. M.	E	30,	4.2 A. M.	E	11,	12.1 P. M.	E
20,	5.7 P. M.	E	May 2,	1.5 A. M.	E	13,	9.4 A. M.	E
22,	2.9 P. M.	E	3,	10.8 P. M.	E	15,	6.8 A. M.	E
24,	12.2 P. M.	E	5,	8.1 P. M.	E			
26,	9.5 A. M.	E	7,	5.5 P. M.	E			

Phases of the Moon.

		Central Time. d	h	m
Full Moon	April	15	4	18.6 P. M.
Last Quarter	"	22	7	55.8 A. M.
New Moon	"	29	8	04.9 P. M.
First Quarter	May	8	12	42.4 A. M.
Full Moon	"	15	12	42.2 A. M.

Note on Observations of Saturn. A few minutes after receiving Krueger's telegram in reference to a white spot on the rings of Saturn, I had a 6½-inch reflecting telescope in use to look up the phenomenon. I had been observing the planet the night before and had not noticed anything peculiar save that the *shadow* of the globe on the ring was very clear and its edge sharply defined. The definition was not nearly so good on the night of the 13th, but at times was good enough to notice a whitish "tint" on the rings bordering the shadow, which I should say was certainly the effect of contrast. I could not use a higher power than 200, and as the definition became worse rather than better I gave it up for the evening. Saturday evening, the 16th, looking fine, I went to the Allegheny Observatory near by, and with Professor Very made quite an extended observation on the

planet with the 13-inch equatorial. Various powers were used up to 900, the atmosphere being quite steady. As Professor Very had no knowledge of the phenomenon, he asked me to say nothing, so as to leave him unbiased in his search for any peculiarity. After using powers up to about 600 he concluded he saw nothing peculiar. I then told him where to look and what to look for, when he concluded he could see an apparent whitening on the border of the shadow, but like myself thought it was due to contrast with the black shadow of the planet. I certainly could see it with all powers above one hundred, though I am not certain that I should not, in an ordinary observation, have set it down at once as the *effect of contrast.* But the question comes in, why has this feature not before been delineated? According to Webb, Grover has seen a penumbra to the shadow, but here we have just the opposite. It cannot be of a like character with the white spot which formed and spread out over the globe of the planet in 1876, and from which Professor Hall determined the time of revolution of the planet, because it could only be seen next the shadow at every revolution of the rings. If it is not the effect of contrast it might be explained upon the basis of a rapid cooling of a vaporous atmosphere from the cold upon that part of the ring in shadow; but even this is not satisfactory on account of the rapidity with which the rings move. At any rate observations of a critical character on such phenomena are always of value and interesting, and in such work the earnest amateur may make himself useful in the domain of the "New Astronomy."

The belts on the planet were exquisitely brought out on the night of the 16th, reminding me of the glorious view I had of it two months since in the 36-inch at the Lick Observatory, only that what we saw here in the 13-inch *dimly*, yonder we saw, as it were, "face to face." Never shall I forget that sight which has been seen by few mortal eyes as we saw it at Mt. Hamilton. J. A. BRASHEAR.

Allegheny, March 20, 1889.

The White Spot on Saturn's Ring, recently announced by Terby of Belgium, was observed at this Observatory on the evening of March 14th both by Professor Brooks (who was

my guest on that night) and myself. In consequence, however, of its faintness, and of the bright moonlight in which it was viewed, it was a difficult object; but as we both saw it in the same position and of the same size and shape, there could be no doubt in the mind of either of us that we had seen the "spot," which appeared as a narrow band extending across both outer rings, its western boundary being in contact with the black notch termed the shadow of the ball on the ring.

As we found the spot in the same place as at discovery, it cannot belong to the ring itself, as the latter revolves, and, so doing, would cause the spot to be seen on all parts of the ring. We are led, therefore, to believe that the phenomenon must be produced by reflected sunlight from the globe of the planet, though in just what manner produced we are not able to determine. LEWIS SWIFT.

Warner Observatory, Rochester, N. Y.,
March 16, 1889.

The "White Region" on Saturn's Ring, announced by Dr. Terby, has been well seen with the 10-inch equatorial of this observatory. My first view of it was through Dr. Swift's 16-inch, while on a brief visit in Rochester. Since my return home I have given it very careful study and it has, at intervals, been a comparatively conspicuous object. My young daughter, Anna, who often observes with me, sees it distinctly.

The brightness appears to me to be variable. Pulsations of the light of this "white region" have been noticed at irregular intervals, ranging from two to seven minutes. Its appearance at my last observation was that of two small nearly semicircular white "tufts," where the ring is cut by the shadow of the globe. WILLIAM R. BROOKS.

Smith Observatory, Geneva, N. Y.,
March 19, 1889.

The Occultation of a Star, estimated at the 8½ magnitude, by the dark limb of the new moon was observed by me on the evening of March 6. Disappearance of the star was taken at 3*h* 11*m* 17*s* local sidereal time. The dark limb of the moon was very distinct and steady, but the star did not

disappear at geometrical contact, but seemed to *sink into* the body of the moon fully three of the star's diameters, and disappearance did not occur until two seconds after geometrical contact. WILLIAM R. BROOKS.

Smith Observatory, Geneva, N. Y.,
March 19, 1889.

EDITORIAL NOTES.

Our space is so largely given to eclipse reports this month that almost all matters of a miscellaneous kind, including the planet notes, must be deferred until the next issue.

We received too late for use in the article by Hon. C. W. Irish, some fine drawings of the corona as seen at Liegan, Cal., by his eclipse party, Jan. 1, 1889.

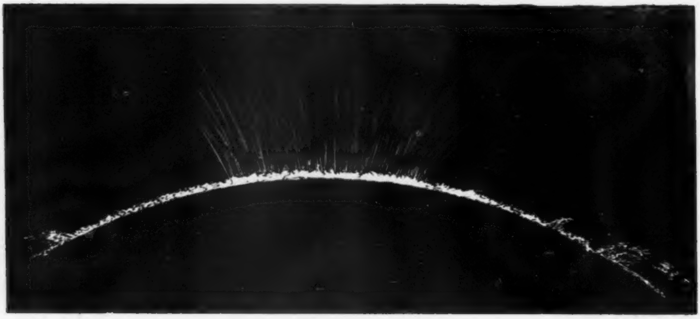
White Region on Saturn's Rings. Harvard College Observatory announced by telegraph, March 13, that Terby had seen a white region on Saturn's rings against the globe shadow.

Although the observers at Carleton Observatory have examined Saturn's rings with the Clarke eight-inch refractor, on four different evenings, in fairly good viewing, with care, nothing has been seen of unusual character. There is the appearance of a lighter color near the shadow of the planet on the rings, but only what might be expected from contrast. It may be that the phenomenon which was first reported by Terby, and later seen in America, by Swift, Brooks and McLeod, is too faint for our aperture. We, however, used powers 200, 400, and 800 with ordinary results.

International Polar Expedition. We are in receipt of Vol. II. of the report by Gen. A. W. Greeley, on the Proceedings of the United States Expedition to Lady Franklin Bay, Grinnell Land. This volume is companion to the one published last year, and completes one of the most important reports in the interest of science and discovery known to American history. Though that heroic party of explorers suffered great privations and the loss of the lives of several of its members, a record has been made that is truly international in character.

Fauth & Company's Small Telescopes. We have recently learned that Messrs. Fauth & Company, Washington, D.C., have made arrangements with the Clarks of Cambridge to supply them with objectives for telescopes ordered of them in the future. We also notice that this company are to give special attention to the mounting of small telescopes well adapted to the wants of students and amateurs. The 4-inch clear aperture, with finder, clockwork, clamp and tangent movements in right ascension and declination, mounted on tripod or iron pillar, as preferred, makes a very useful and comparatively inexpensive telescope. Should an astronomical clock, chronograph, spectroscope, or even a wooden observatory for small instruments be wanted, these well known and reliable makers of precision instruments will certainly not disappoint any one entrusting work to them.

South Polar Rays of the Corona, by Mr. Brashear. After sending his brief report of the observations of the January eclipse made at Winnemucca, Mr. Brashear had the kindness to send us his drawing of the south polar rays of the corona which is given below:



Concerning this astonishing phenomenon, it will be remembered that he said in his last report, that his sketching arrangements consisted of a piece of plate glass, half of which was finely ground and the other half left plain, the line between the two being a curve representing the moon. This made a splendid sketching plate when it was feebly illuminated by a lamp behind it, and it could be used as a photographic negative reproducing in white the black final lines. The figure shows something of the detail of the polar rays and two beautiful solar protuberances.